

## ACID SULFATE WEATHERING ON MARS: RESULTS FROM THE MARS EXPLORATION ROVER MISSION

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Sulfur has played a major role in the formation and alteration of outcrops, rocks, and soils at the Mars Exploration Rover landing sites on Meridiani Planum and in Gusev crater. Jarosite, hematite, and evaporite sulfates (e.g., Mg and Ca sulfates) occur along with siliciclastic sediments in outcrops at Meridiani Planum [1,2]. The occurrence of jarosite is a strong indicator for an acid sulfate weathering environment at Meridiani Planum. Some outcrops and rocks in the Columbia Hills in Gusev crater appear to be extensively altered as suggested by their relative “softness” as compared to crater floor basalts, high  $\text{Fe}^{3+}/\text{Fe}_T$ , iron mineralogy dominated by nanophase  $\text{Fe}^{3+}$  oxides, hematite and/or goethite, corundum-normative mineralogies, and the presence of Mg- and Ca-sulfates [3,4]. One scenario for aqueous alteration of these rocks and outcrops is that vapors and/or fluids rich in  $\text{SO}_2$  (volcanic source) and water interacted with rocks that were basaltic in bulk composition [3]. Ferric-, Mg-, and Ca-sulfates, phosphates, and amorphous Si occur in several high albedo “soils” disturbed by the rover’s wheels in the Columbia Hills [3]. The mineralogy of these materials suggests the movement of liquid water within the host material and the subsequent evaporation of solutions rich in Fe, Mg, Ca, S, P, and Si. The presence of ferric sulfates suggests that these phases precipitated from highly oxidized, low-pH solutions. Several hypotheses that invoke acid sulfate weathering environments have been suggested for the aqueous formation of sulfate-bearing phases on the surface of Mars including (1) the oxidative weathering of ultramafic igneous rocks containing sulfides; (2) sulfuric acid weathering of basaltic materials by solutions enriched by volcanic gases (e.g.,  $\text{SO}_2$ ); and (3) acid fog (i.e., vapors rich in  $\text{H}_2\text{SO}_4$ ) weathering of basaltic or basaltic-derived materials [3,5,6,7,8].

[1] G. Klingelhöfer et al., *Science*, **306**: 1740-1745 (2004). [2] B. C. Clark et al., *Earth & Planet. Sci. Lett.*, **240**, 73-94 (2005). [3] D. W. Ming et al., *J. Geophys. Res.*, **111**, E02S12, doi:10.1029/2005JE002560 (2006). [4] R. V. Morris et al., *J. Geophys. Res.*, **111**, E02S13, doi:10.1029/2005JE002584 (2006). [5] R. G. Burns, *Proc. Lunar & Planet. Sci XVIII*, 713-721 (1988). [6] N. J. Tosca et al., *Earth & Planet. Sci. Lett.* **240**, 122-148 (2005). [7] J. A. Hurowitz et al., *J. Geophys. Res.*, **111**, E02S19, doi:10.1029/2005JE002515 (2006). [8] D. C. Golden et al., *J. Geophys. Res.*, **Vol. 110**, E12S07, doi:10.1029/2005JE002451 (2005).